Case Study – Rangely Weber Sand Unit CO_2 Injection Project, Colorado

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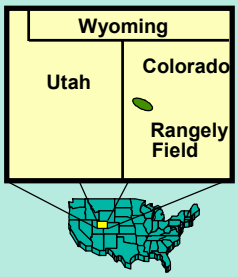
Rangely Weber Sand Unit

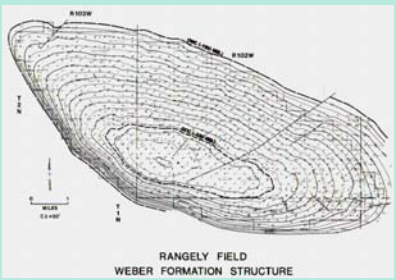
Largest field in the Rocky Mountain Region and one of the largest in the lower 48 states.

- Discovered in 1933.
- Developed in the 1940's.
- Hydrocarbon gas injection for pressure support in 1950's.
- Unitized for waterflooding in late 1950's.
- CO_2 Enhanced Oil Recovery started in 1986.

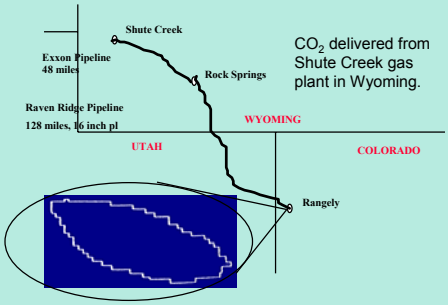


Rangely Field Reservoir Data

Producing Formation	Weber Sandstone
Average Depth	6400 ft
Reservoir Thickness	526ft (189 ft net)
Porosity / Permeability	12% / 8 md
Original Oil in Place	1,879 MMSTB
Asymetrical Anticline	19,153 acres
Original Gas Cap	
Six correlatable reservoir layers separated by non-reservoir layers	



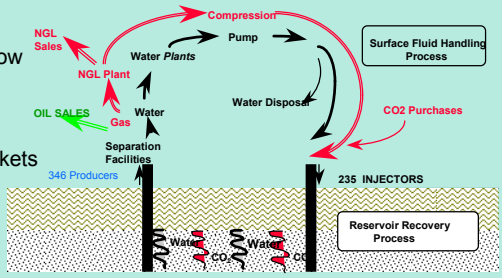
Facilities Overview



CO_2 delivered from Shute Creek gas plant in Wyoming.

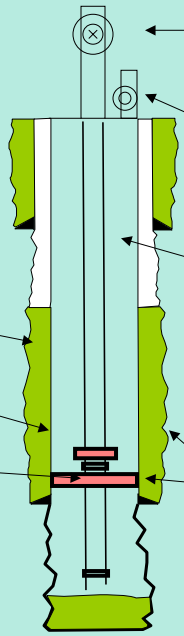
Materials:

- Low-temperature resistant carbon steel for low moisture CO_2 service
- Stainless steel where CO_2 & water mix
- Peroxide-cured Buna-n rubber products/gaskets
- H_2S service SS valve trim
- Lined Carbon Steel or Fiberglass for other produced/injected fluids



Efforts to Contain CO_2

Key Initiatives:
- Pre-Injection Well Integrity Verification
- Monitoring & management of injection / annulus pressures
- Injection profile surveys
- Mechanical integrity tests
- Around the clock field monitoring



Monitoring by personnel.

Mechanical integrity test run upon repairs / new installations or every 5 yrs.

Corrosion inhibitor in annulus guards casing.

Cement Bond Logs verify quality of cement job.

Casing Inspection logs confirm a good spot to set packer.

Packers isolate the casing / tubing annulus from pressure / fluids.

Injection profiles annually check for packer leaks & verifies isolation of zones above injection interval.

Investigation of Microseepage

Researcher: Dr. Ronald W. Klusman,
Colorado School of Mines

Objectives: *1.* Assess fate of CO_2 injected.
2. Investigate microseepage.

Microseepage – A low rate of gas seepage that may occur through fractures in the cap rock and overlying formations.

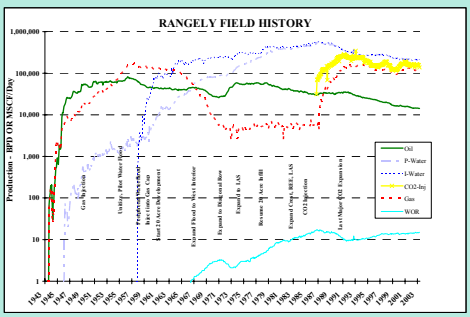
Conclusions

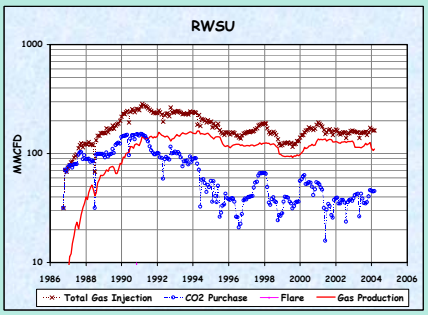
1. Deep sourced CO_2 flux to the atmosphere was estimated between 170 & 3800 metric tons per year over the 78 km^2 area. The lower limit is likely lower based on modeled rates for CO2 generation from methanotrophic oxidation in soil.
2. Deep-sourced methane flux to the atmosphere was estimated at 400 metric tons per year. (This was attributed to "overpressuring" of the reservoir with CO_2 injection but could be natural release from shallow gas reservoirs or gas previously injected for pressure support.)
3. "Substantial economic value can be realized through hydrocarbon production, and a moderate amount of CO_2 can be sequestered as dissolved CO_2." (Computer modeling indicates that much of the CO_2 injected is currently stored as dissolved CO_2 and that this will increase with time).

Current Operations

March '04 Production / Injection:

Oil Production	13,564 B/D
NGL Production	1,211 B/D
Water Production	227,200 B/D
Gas Production	109 MMCF/D (3.1 MMm^3/d)
CO_2 Purchases	45 MMCF/D (1.3 MMm^3/d)





Cumulative Information (March, 2004):

Oil Production	851 MMB (45.3%)
NGL Production	8.2 MMB
Water Production	3.8 BB
CO_2 Purchase	432 BCF (12.2 Bm^3 = 24.7 MM tons)
Gas Prod (since CO2)	708 BCF (20.0 Bm^3)
CO_2 Injection	1.1 TCF (31.1 Bm^3)
CO_2 Sequestered	426 BCF (22.5 MM tons)

References on Rangely Microseepage Research

- Klusman, R.W., 2003, Possible Vertical Migration of CO_2 Associated with Large-Scale Inection Into Subsurface Geologic Formations. Final Report for DOE Grant DE-FG03-00ER15090
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